STATOTHR

[redacted]

Report on Phase II Trial #2

DIFFRACTION GRATINGS

for

DIRECT IMAGE VIEWER

Report on Phase II

Trial #2

STATOTHR

[redacted]

1.0 The Diamond Tool

Two diamond tools were made, using the same fixturing and measuring equipment developed for trial #1. Some difficulty was encountered due to the doubled size of the tool required, and the problem of measuring to the same accuracy over twice the distance.

2.0 The Ruling Set Up

The same procedure was used as for trial #1, in that test grooves and test areas were ruled and over-ruled under various conditions of tool orientation and loading. The aluminum coating for ruling had to be twice as thick as previous, and we were successful in making the thicker coating without having excessive surface roughness. It was found that the ruling engine gearing necessary for ruling the required groove spacing of 72.4u was incommensurate. Mathematically, the combined gear ratio was an unending decimal. This meant that the gearing could never be returned for over-ruling. Therefore the test ruling had to be ruled at the nearest possible commensurate interval, namely 73.33u. It was felt that this change of $1\frac{1}{4}\%$ would not affect the value of the test ruling. If and when the final 10 inch rulings are made, we will then be able to rule at the prescribed interval of 72.4u. ?

2.1 Set Up Control

We were fortunate to have available a new interference microscope received here just prior to the actual set-up. Due to the new microscope and the increased groove size, we were able to measure and photograph the groove contour with interference fringes in air. This removed the conversion problem and possible errors in determining just what the wavelength really is in an oil medium. A new and much more accurate method for measuring fringe location was worked out. This consisted of orienting the fringes parallel to the grooves and then measuring the parallel fringe micro-interferogram using a contour projector. Sample micro-interferograms are included with this report, along with a graph plotted from information obtained from the micro-interferogram as measured with a contour projector. For comparison this graph also includes a curve which is a true arc, calculated from the measured width and depth of the groove.

3.0 Ruling and Replication STATOTHR

A master ruling [redacted]) was made, using the double ruling techniques. The ruled area is 53x53mm and on a 58x58mm blank. Three transmission replicas of this ruling were made on blanks 58x58x10mm thick. The 3rd replica was second generation so that we could compare it to a 1st generation replica.

4.0 Grating Tests

The distribution of energy among the orders of the transmission replicas was measured, and for six discrete wavelengths in steps of 10mu, between 500 and 550mu. The results were plotted on a bar graph included with this report. The sum of adjacent orders is also plotted on the bar graph to simulate the energy distribution as the grating will actually be used.

4.1 Test 4.0 was also simulated numerically and computed, assuming a theoretically correct groove shape. Results were plotted on a bar grpah for comparison to 4.0, along with a plot of the sum of adjacent orders.

5.0 Test Results

As determined graphically from the micro-interferograms, the groove contour departs from a true arc by 0.07u. However the groove is much more symmetrical than our 1st trial. Departure from symmetry, maximum, is 0.01u. Also the groove contour closely resembles an oblate concave curve as a smooth symmetrical curve should perform well. For comparison, trial #2 is about six times more symmetrical than trial #1.

5.1 The measured energy distribution among the orders for transmission grating #995 was examined for variation of the important ratios between them. Unlike the previous ruling, there is not much change of ratio with wavelength. The following table gives the maximum ratios for adjacent orders and for the highest vs lowest order.

The ratios include both measured and calculated theoretic values for the orders and for six discrete wavelengths.

Wavelength	Measured Ratios Adjacent orders	Measured Ratios Hi/Lo orders	Theoretical Ratios Adjacent orders	Theoretical Ratios Hi/Lo orders
5000A	1.73/1	2.32/1	1.52/1	1.91/1
5100A	2.00/1	2.26/1	1.52/1	1.81/1
5200A	2.16/1	2.16/1	1.52/1	1.92/1
5300A	2.13/1	2.17/1	1.59/1	2.00/1
5400A	1.95/1	2.30/1	1.54/1	1.92/1
5500A	1.75/1	2.24/1	1.58/1	2.22/1

Since this grating will be used with adjacent orders overlapping, the following table gives the ratios for this case.

Wavelength	Measured Ratios Adjacent orders	Measured Ratios Hi/Lo orders	Theoretical Ratios Adjacent orders	Theoretical Ratios Hi/Lo orders
5000A	1.48/1	2.07/1	1.37/1	1.70/1
5100A	1.34/1	1.92/1	1.39/1	1.71/1
5200A	1.37/1	1.97/1	1.43/1	1.76/1
5300A	1.42/1	1.99/1	1.47/1	2.02/1
5400A	1.47/1	1.91/1	1.35/1	2.36/1
5500A	1.48/1	1.83/1	1.35/1	2.64/1

5.1.1 The above table shows that in some cases the test ruling exceeds theory and in all cases closely approaches theory. While it is not obvious from the tables, there is the possibility of improving the ratios still more by choosing the best wavelength range. This is because the worst cases as picked for the table above, change their positions in the orders as the discrete wavelengths are changed. This is particularly true for adjacent orders.

5.1.2 We have also calculated the relative luminosity of each of the averaged orders over the wavelength range 500-550 millimicrons.

5.2 The second generation transmission replica was measured and the order energy distribution compared to that for the first generation. When compared order for order, the average difference in energy was only 3.6% of the energy in each order. Theoretical calculations predicted no difference between first and second generation and the data above bears this out within experimental accuracy.

6.0 Conclusions and Recommendations

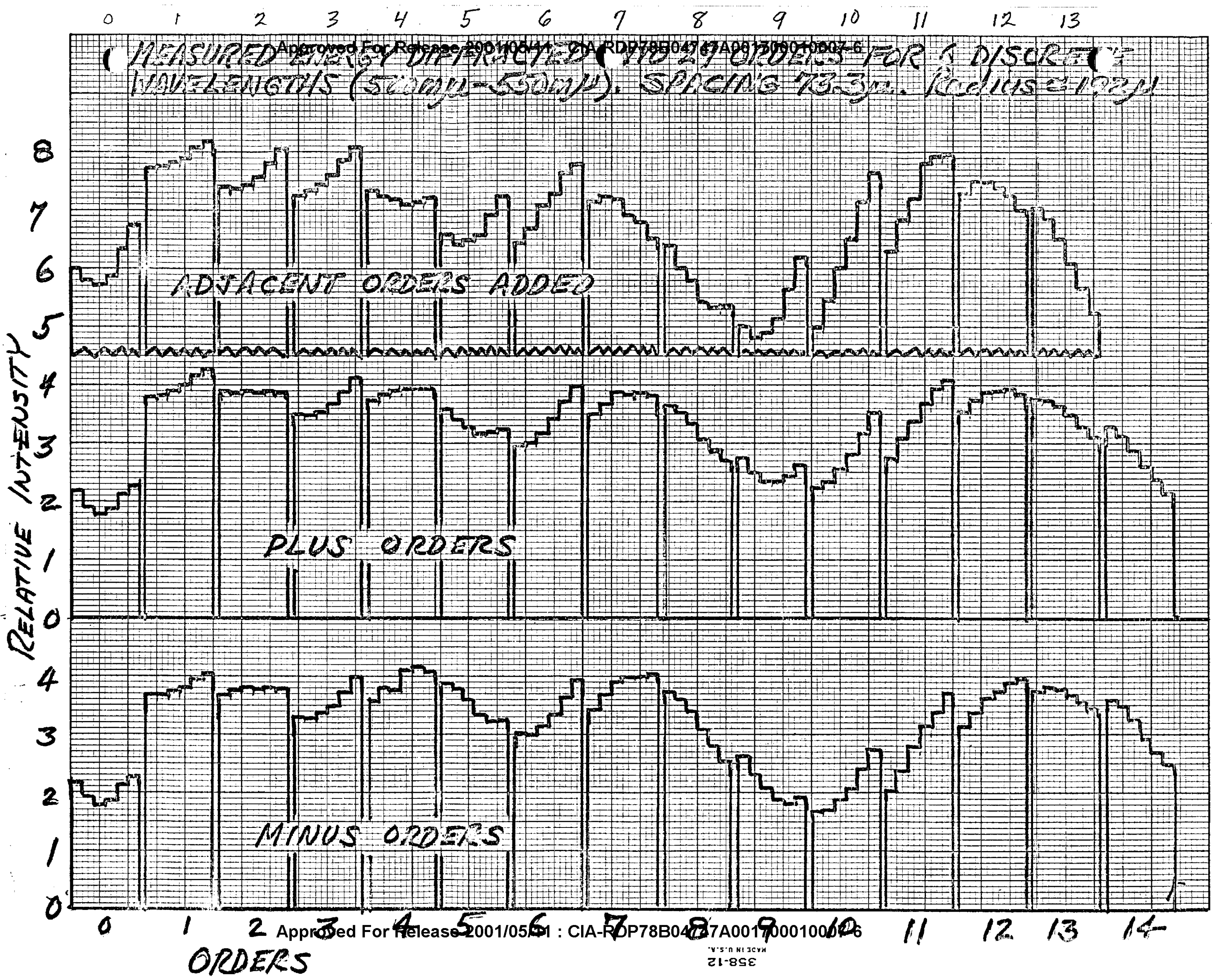
We feel that test #2 is successful beyond our fondest expectations. Original design goals are met or exceeded in all respects. The energy distribution in the orders is more uniform than theory in the best cases and in the worst cases is 91% of theory for adjacent orders and 82% of theory for the overall order energy ratio. We therefore recommend proceeding to Phase III, the manufacture of a 10x10 inch ruling and associated replica gratings.

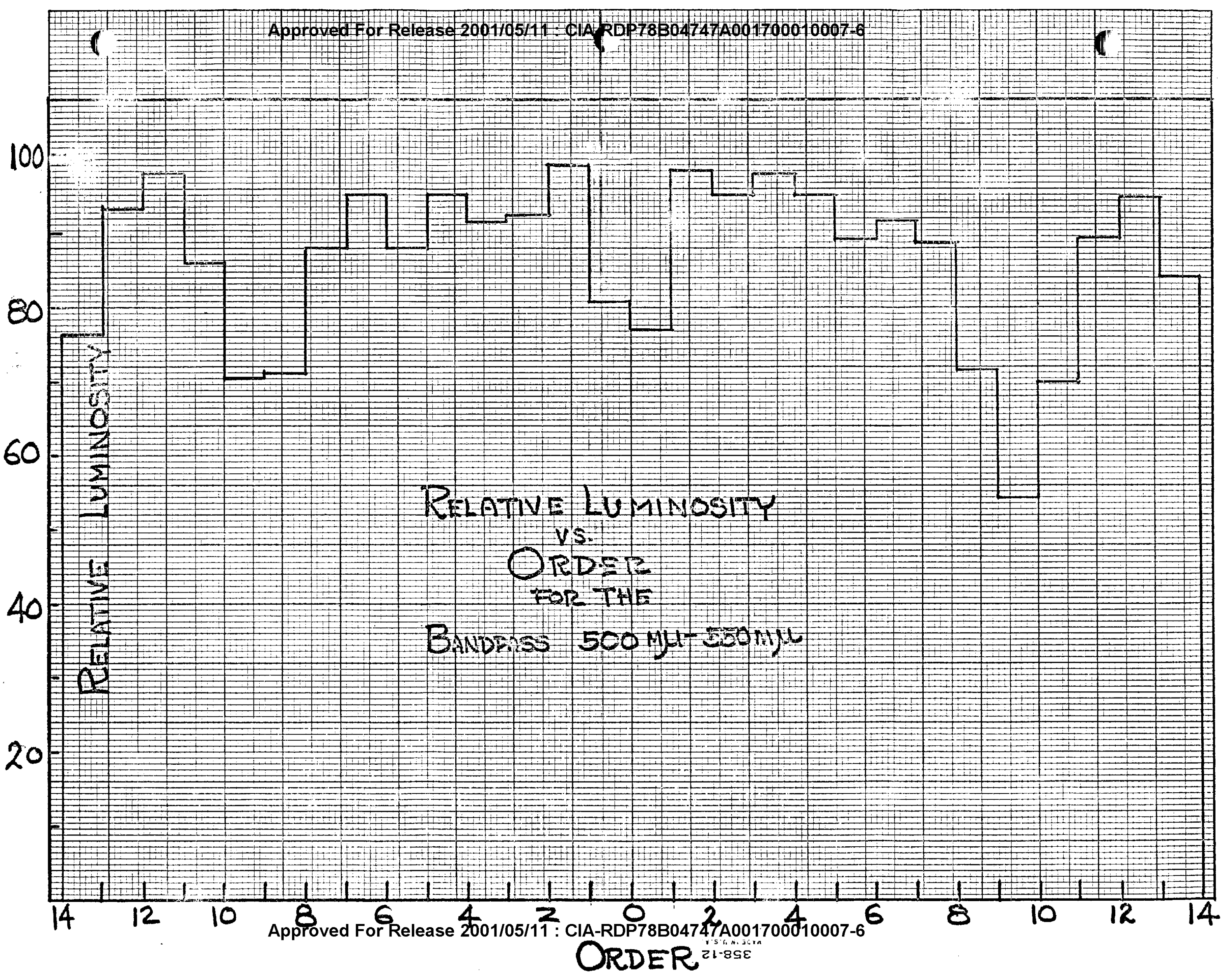
The following are appended to this report:

1. Micro-interferograms of groove profile and graphs plotted from micro-interferograms.
2. Bar Graph - Calculated order intensities for discrete wavelengths and calculated order intensities where adjacent orders are added.

3. Bar Graph - Measured order intensities for discrete wavelengths and measured order intensities where adjacent orders are added.

4. Bar Graph - Relative luminosity vs order for the Bandpass 500-550 millimicrons.

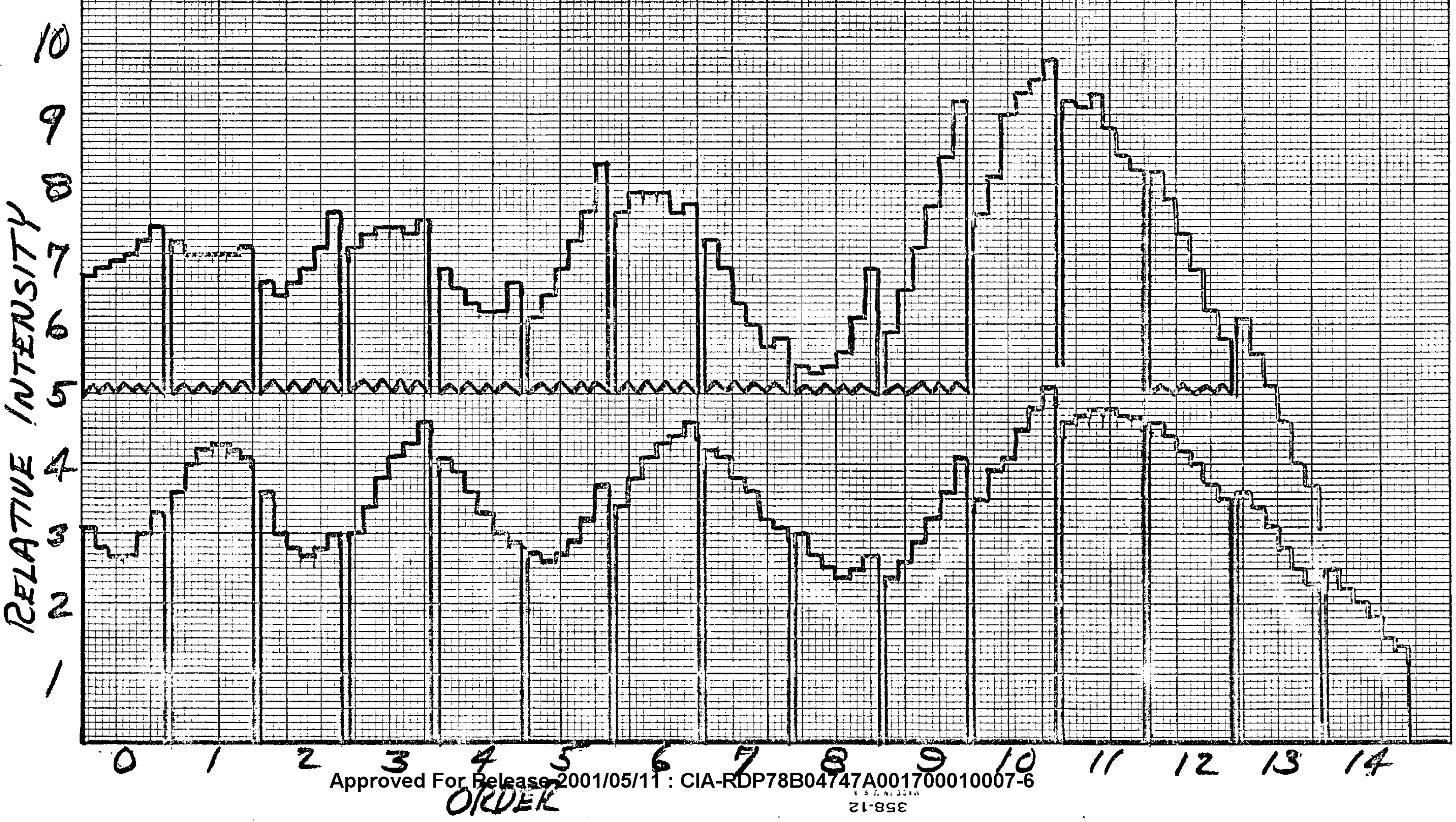

0 1 2 3 4 5 6 7 8 9 10 11 12 13
MEASURED ENERGY DIFFRACTED INTO 29 ORDERS FOR 5 DISCRETE WAVELENGTHS (500mμ-530mμ). SPACING 73.3μ. Radius=192μ
ADJACENT ORDERS ADDED
PLUS ORDERS
MINUS ORDERS
RELATIVE INTENSITY
8 7 6 5 4 3 2 1 0
4 3 2 1 0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
ORDERS
358-12
MADE IN U.S.A.



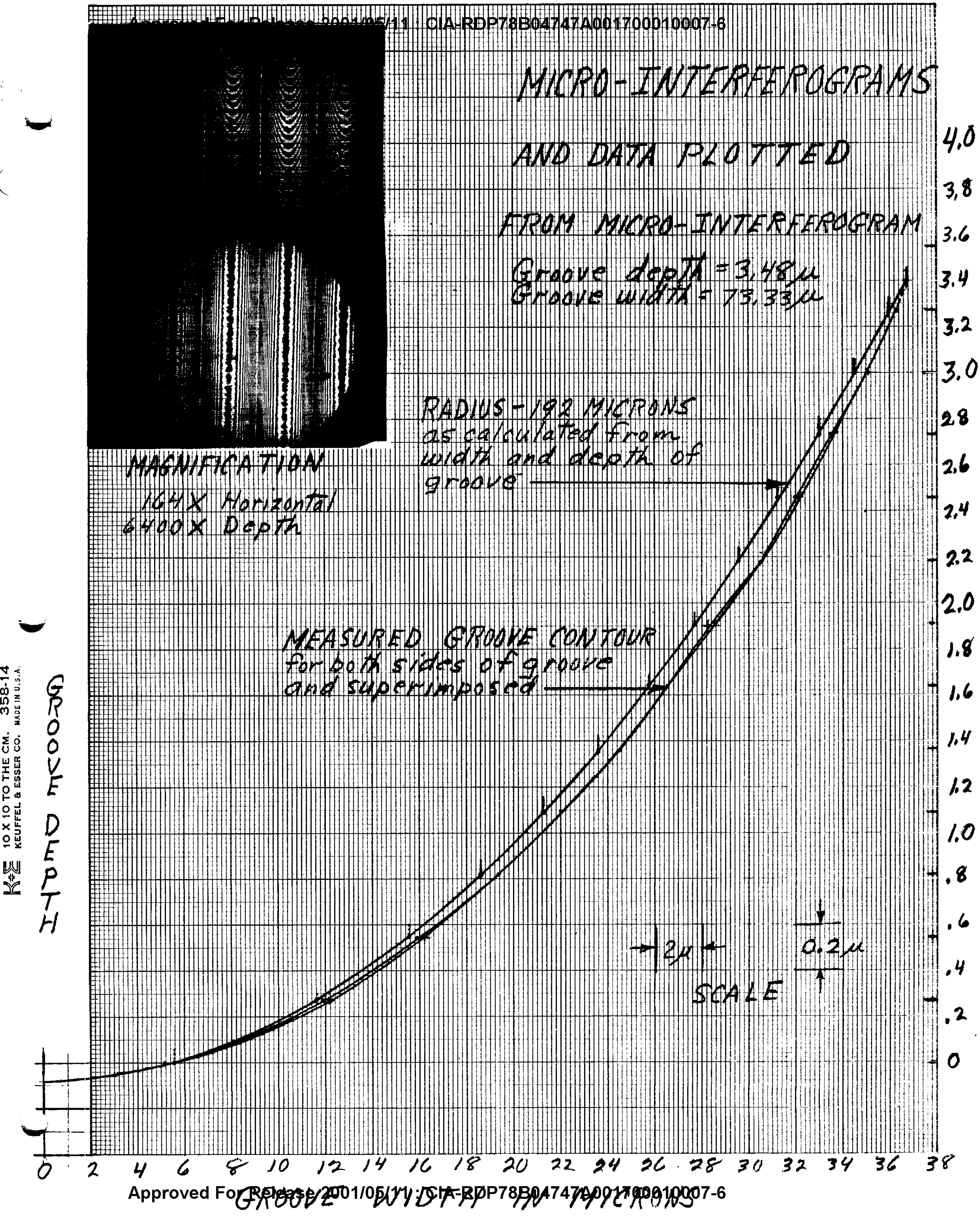
Approved For Release 2001/05/11 : CIA-RDP78B04747A001700010007-6

CALCULATED ENERGY DIFFRACTED INTO 29 ORDERS FOR SIX DISCRETE WAVELENGTHS ([illegible]) - SPACING [illegible] - RADIUS [illegible]

LOWER GRAPH - AS CALCULATED
UPPER GRAPH - ADJACENT ORDERS ADDED TOGETHER
(CALCULATION IS SYMMETRIC - ONE SIDE SHOWN)



358-12


MICRO-INTERFEROGRAMS
AND DATA PLOTTED
FROM MICRO-INTERFEROGRAM
Groove depth = 3.48μ
Groove width = 73.33μ
RADIUS - 192 MICRONS
as calculated from
width and depth of
groove
MAGNIFICATION
164X Horizontal
6400X Depth
MEASURED GROOVE CONTOUR
for both sides of groove
and superimposed
2μ
0.2μ
SCALE
GROOVE DEPTH
GROOVE WIDTH IN MICRONS
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
10 X 10 TO THE CM. 358-14
KEUFFEL & ESSER CO. MADE IN U.S.A.